

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
24 December 2003 (24.12.2003)

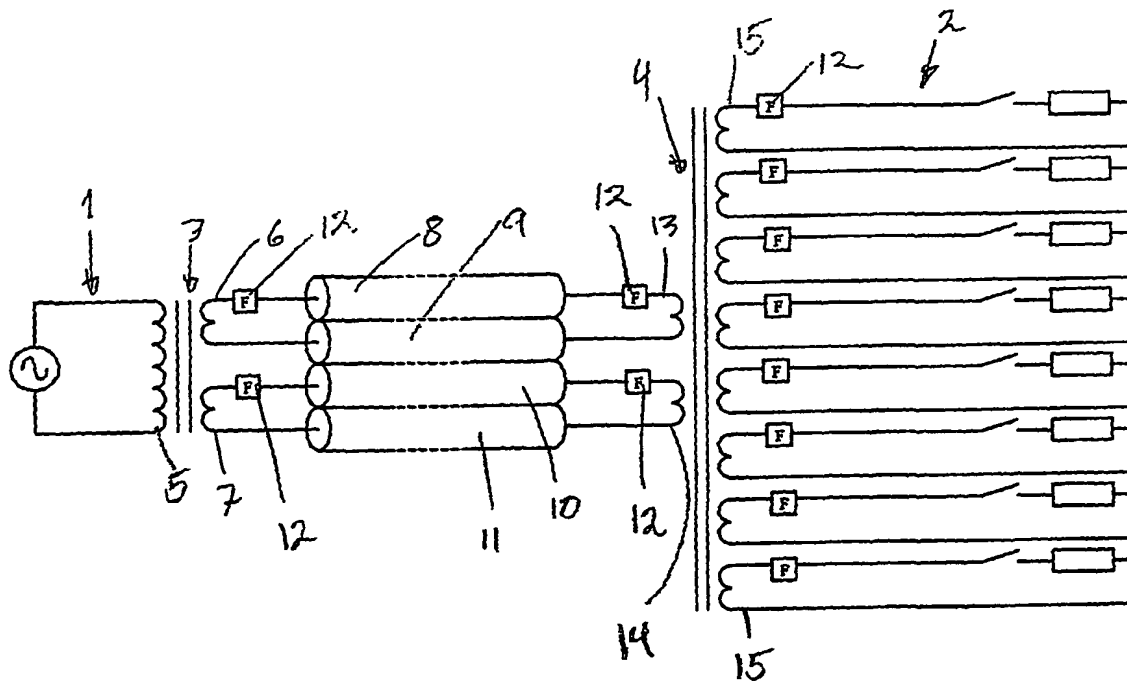
PCT

(10) International Publication Number
WO 03/106813 A1

- (51) International Patent Classification⁷: **E21B 47/12, H04B 3/54** (74) Agent: **PROTECTOR IP CONSULTANTS AS**; P.O.Box 5074 Majorstuen, N-0301 Oslo (NO).
- (21) International Application Number: **PCT/NO03/00199** (81) Designated States (*national*): AE, AG, AL, AM, AT (utility model), AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ (utility model), CZ, DE (utility model), DE, DK (utility model), DK, DM, DZ, EC, EE (utility model), EE, ES, FI (utility model), FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK (utility model), SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.
- (22) International Filing Date: **16 June 2003 (16.06.2003)**
- (25) Filing Language: **English**
- (26) Publication Language: **English**
- (30) Priority Data:
2002 2909 17 June 2002 (17.06.2002) NO
- (71) Applicant (*for all designated States except US*): **KVÆRNER OILFIELD PRODUCTS AS** [NO/NO]; P.O.Box 94, N-1325 Lysaker (NO).
- (72) Inventors; and
- (75) Inventors/Applicants (*for US only*): **BAKKA, Olav** [NO/NO]; Morgedalsveien 43 1.3, N-0378 Oslo (NO). **NORMAN, Truls** [NO/NO]; Urtegaten 6B Leil 7005, N-0187 Oslo (NO).
- (84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: **INTEGRATED COMMUNICATIONS AND POWER SYSTEM**



(57) Abstract: In order to avoid signal disturbances at communications through electric high power cables for supply of electric power to offshore installations, power cables that are galvanically insulated from each other are used. For example this may be done by supplying power at two single-phase pairs and use one conductor in every pair as signal conductor or by using a three-phase cable plus a single conductor.

WO 03/106813 A1

**Declaration under Rule 4.17:**

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU,

TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)

Published:

- with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Integrated communication and power system

- 5 The present invention relates to a system that combines transmission of power and signals via a custom designed cable configuration to offshore, especially subsea located control units.

10 To reduce the outlet of carbondioxide and other environmentally unfriendly gases, the authorities have encouraged and imposed a supply of electrical power from onshore power plants to offshore installations. For a subsea installation a power supply via a cable from land is usually the only possibility.

15 In addition to the power supply offshore installations are more and more dependent on data communication with land based facilities. Subsea installations may be fully controlled from land. This requires a large amount of data to be sent between the installation and land.

20 The principle of simultaneously utilizing power transmission cables and lines for communication purposes is commonly known under the terms "comms-on-power" or PLC (Power Line Carrier). Onshore this has been performed since long ago. Offshore it is typically applied as supplement to optical fiber cable, but may also be installed as the only system. Installed as the only system it has certain technical advantages, e.g. it may reduce the number of subsea wet mateable connectors required. The power and
25 communications is subsequently distributed to each control unit.

Over very long distances – typically above 100 km – a combined power supply and signal communication is very difficult and the signals are subjected to disturbance from the electric current. On shore this can be solved by inserting amplifiers at certain
30 intervals. Offshore amplifiers are not desired, since this would mean installing delicate equipment at the seabed where access for maintenance is extremely difficult.

The present invention aims to solve this problem without or at least with a substantially reduced need for amplification of the communication signals.

5 The invention provides overall system design considerations and implementations that have been made to achieve and optimize the above described dual functionality by utilizing a set of, preferably, four copper conductors for both power and communication signal transfer.

10 A further advantage of the present invention is that utilization of two conductor pairs introduces redundancy and robustness both with respect to power supply and communication, enabling continued operation of the ICPS (Integrated Communications and Power System) after the occurrence of a single failure.

15 The invention will now be described in detail under reference to the accompanying drawings showing illustrating embodiments of the invention, in which:

Figure 1 shows a first embodiment in a so-called quad arrangement,

Figure 2 shows an alternative embodiment in a 3 phase plus single cable arrangement,

Figure 3 shows schematically a cross section through a cable implementing the arrangement for figure 1,

20 Figure 4 shows schematically a cross section through a cable implementing the arrangement for figure 2, and

Figure 5 shows schematically a transformer to be used with the arrangement of figure 1.

Two alternative ways of arranging the conductors are shown in figures 1 and 2, respectively; figure 1 showing a quad system with two pairs of conductors and figure 2
25 showing a three phase arrangement with an additional single conductor. In both alternatives the connections are arranged and connected in an unusual way to obtain the desired ICPS system optimum. The 3 phase + 1 conductor system can be used for longer distance than the quad in the cases where the cable insulation has an outer semiconductor.

As illustrated in figure 1 and 2, the ICPS power is supplied at the onshore / topside end 1 and extracted at the subsea end 2 via multi-winding, load-balancing transformers 3 and 4.

- 5 In the embodiment of figure 1 the transformer 3 has a primary winding 5 and two secondary windings 6 and 7. The secondary windings are connected to a respective pair of conductors 8, 9 and 10, 11. Each of the secondary windings 6, 7 is equipped with a filter 12. The transformer 4 has two primary windings 13 and 14 and a plurality of secondary windings 15. Each of the primary windings 13, 14 and each of the secondary
10 windings 15 is equipped with a filter 12.

The secondary windings 15 are distributing power and signals to the various equipment on the installation.

- 15 In the embodiment of figure 2 the transformer 3 has three phase primary winding 16 and a three phase secondary winding 17. The three phase secondary winding 17 is connected to three conductors 18, 19 and 20. In parallel to the three conductors 18, 19, 20 is a single conductor 21. At each end of the conductors 18 – 21 is a filter 12.
- 20 The transformer 4 has a three phase primary winding 22 and a plurality of single phase secondary windings 15. Each of the secondary windings is equipped with a filter 12. As for the embodiment of figure 1, the secondary windings 15 are distributing power and signals to the various equipment on the installation.
- 25 Figure 3 show schematically a cross section through the cable containing the conductors 8 – 11 in figure 1. In this figure 1L1 and 1L2 denotes the two conductors 8 and 9 respectively, and 2L1 and 2L2 denotes the two conductors 10 and 11, respectively.

Figure 3 shows schematically a cross section through a cable containing the conductors 18 – 21 in figure 2. In this figure L1, L2 and L3 denotes the conductors 18, 19 and 20, respectively, and S denotes the single conductor 21.

- 5 The conductors are preferably integrated in a common cable, like the one described in Norwegian Patent Application No. 2002 0781.

Figure 5 shows schematically a transformer useful as the transformer 4 in figure 1. The transformer comprises an iron core 23, a first primary winding 13, a second primary
10 winding 14 and a plurality of secondary windings 15.

The function and characteristics of the ICPS can be described as following:

Fixed frequency power for energizing and operation of subsea located control and communication devices is supplied to the primary winding. The connection of the
15 power is different from the connection of the comm's on power.

a), quad: The fixed frequency power is transferred on two insulated copper conductor pairs contained in a single cable. Each pair is supplied from a dedicated power transformer winding, meaning that the two pairs are galvanically separated from each
20 other. A filter for insertion of the communications signals is connected in-between each transformer winding and conductor pair.

b), 3+1: Power is supplied as a standard 3 phase supply. A separate core solely used for the comms' on power system forms part of the umbilical.

- 25 Transfer of communication signals within a designated frequency band via the same set of conductors used for power transmission in item.

Power and communication signals are separated at both cable ends by means of termination to custom designed filters.

5 The cable leading from an onshore or topside located power source is connected to a custom designed, multi-winding power transformer at its subsea located end.

- 10 a) For the quad: An integrated power and signal cable having four insulated copper conductors in fixed radial position relative to each other along the full length of the cable, as illustrated by the cross-section in figure 3. The conductors are operated in pairs as indicated, both with respect to power supply and communications signals. The signals use one conductor in each par, thus using galvanic separated signal conductors with minimum interference of the signal.
- 15 b) For the 3+1: As illustrated by the cross-section in figure 4 the single core is not located close to the 3 cores used for the power supply. The distance between the single core and the 3 power cores is determined by a number of factors such as: - minimum umbilical outer diameter, - - minimum capacitance, minimum inductance. The advantage is that the distance between the 3 cores and the standalone core can be varied, thus inductance for the comms system can be optimized.
- 20 The subsea multi-winding transformer design illustrated by figures 1 and 2 ensures that all subsea located control units are galvanically separated, and thus that the consequences of a single fault is limited to the faulty consumer.
- 25 a) For the quad: The split primary winding connections, winding 1 marked 1L1, 1L2 and winding 2 marked 2L2, 2L1 (see Figure 5) , means that any control unit can be fed from either power transmission conductor pair, thus limiting the effect of a single failure to any one of these pairs. (In the traditional case of a single primary winding and parallel connected power transmission conductor pairs, this robustness would be lost.)

C l a i m s

1.

Integrated communication and power system, comprising at least one first transformer
5 located on shore, at least one second transformer located offshore, conductors
connecting the first transformer with the second transformer, said conductors
conducting electric power and communication signals, c h a r a c t e r i z e d i n at
least four conductors of which at least three conduct electric power, at least one of said
conductors being galvanically insulated from at least one of the other conductors, the
10 communication signals being conducted in two galvanically insulated conductors.

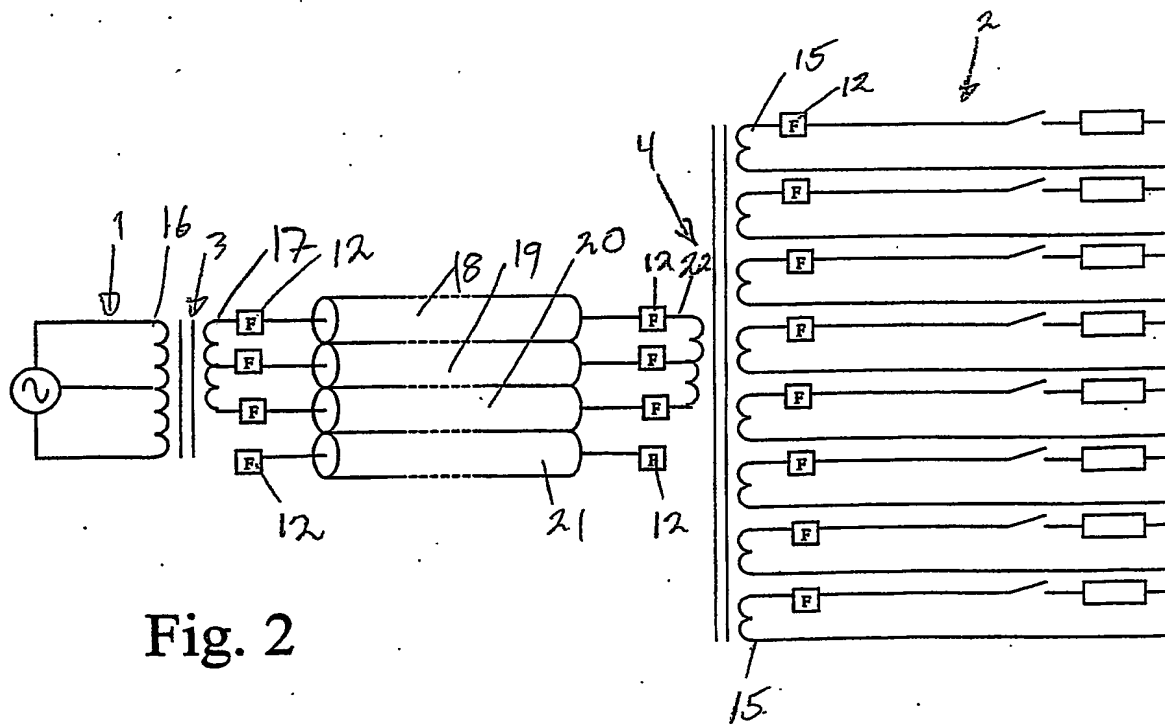
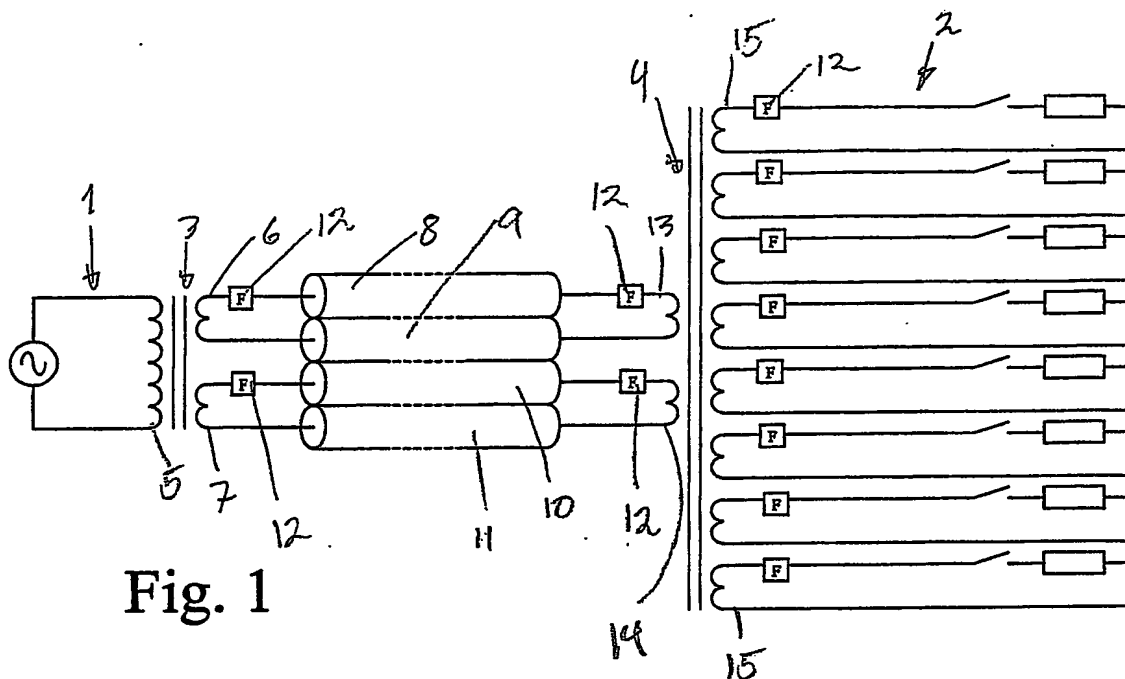
2.

System according to claim 1, c h a r a c t e r i z e d i n that the conductors form at least
two pairs in a double single phase (quad) arrangement.

15

3.

System according to claim 1, c h a r a c t e r i z e d i n that the conductors form a three
phase arrangement plus a single conductor.



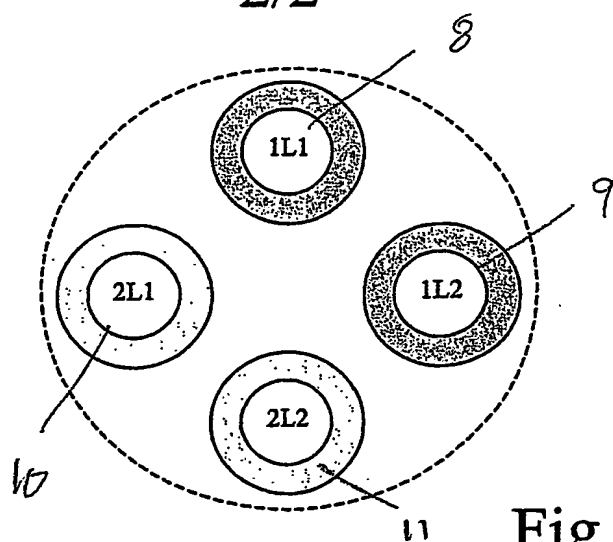


Fig. 3

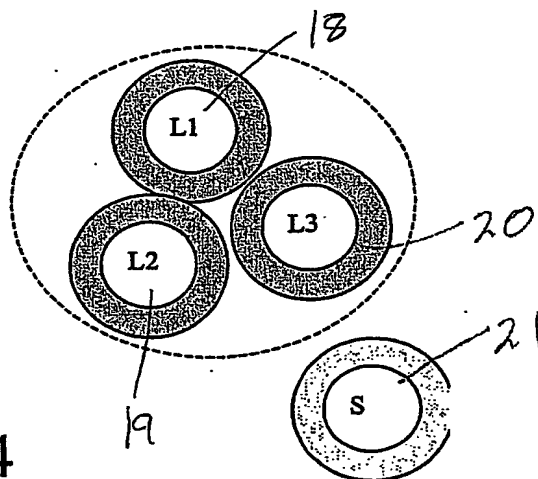


Fig. 4

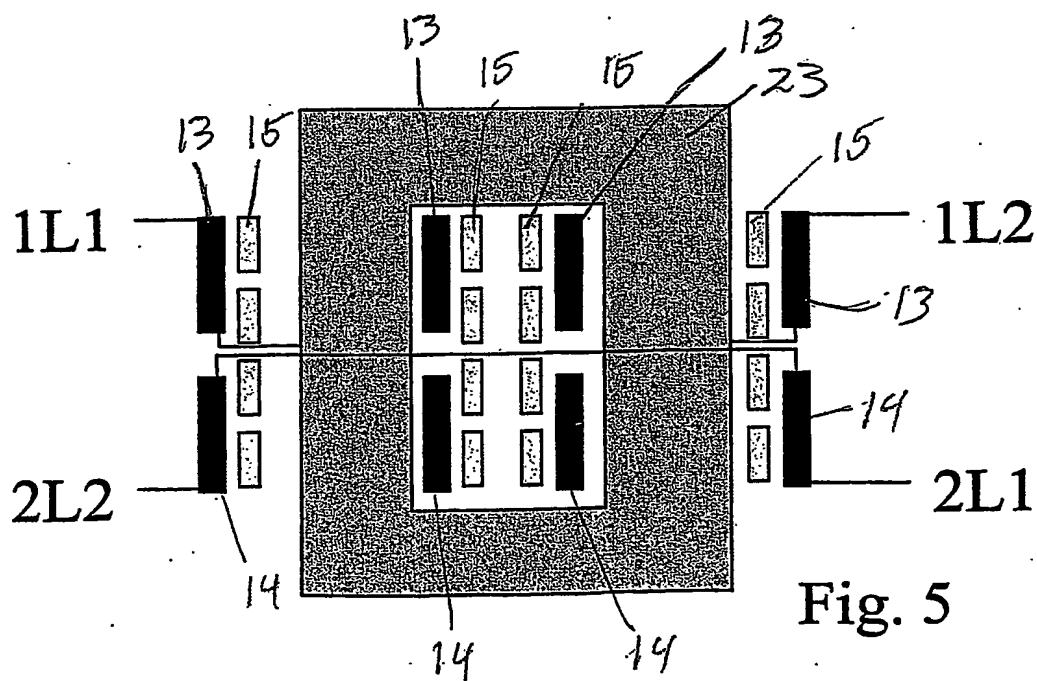


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 03/00199

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: E21B 47/12, H04B 3/54
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: E21B, H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 0103323 A1 (THE AUTONOMOUS WELL COMPANY LIMITED), 11 January 2001 (11.01.01) --	1-3
A	US 5521592 A (VENERUSO), 28 May 1996 (28.05.96) --	1-3
A	US 5444184 A (HASSEL), 22 August 1995 (22.08.95) --	1-3
A	US 5515038 A (SMITH), 7 May 1996 (07.05.96) -- -----	1-3

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
 "B" earlier application or patent but published on or after the international filing date
 "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
 "O" document referring to an oral disclosure, use, exhibition or other means
 "P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

25 August 2003

Name and mailing address of the ISA/
 Swedish Patent Office
 Box 5055, S-102 42 STOCKHOLM
 Facsimile No. +46 8 666 02 86

Date of mailing of the international search report

27-08-2003

Authorized officer

Christer Bäcknert / JA A
 Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

26/07/03

International application No.

PCT/NO 03/00199

Patent document cited in search report			Publication date	Patent family member(s)		Publication date
WO	0103323	A1	11/01/01	AU	5693900 A	22/01/01
				CA	2377895 A	11/01/01
				EP	1197011 A	17/04/02
				GB	9915298 D	00/00/00
US	5521592	A	28/05/96	CA	2128473 A	28/01/95
				FR	2708310 A,B	03/02/95
				GB	2280577 A,B	01/02/95
				GB	9414774 D	00/00/00
				NO	307479 B	10/04/00
				NO	942777 A	30/01/95
US	5444184	A	22/08/95	FR	2688960 A,B	24/09/93
				GB	2264424 A,B	25/08/93
				GB	9302114 D	00/00/00
				NO	174488 B,C	31/01/94
				NO	920544 A	13/08/93
US	5515038	A	07/05/96	GB	2283889 A,B	17/05/95
				GB	9423047 D	00/00/00